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(56) Documents Cited
GB 1424754 A GB 0788782 A GB 0559261 A
EP 0498581 A EP 0399815 A EP 0372727 A
EP 0291205 A WO 95/30255 A WO 88/01939 A
US 4653854 A US 4263345 A US 3934065 A

(58) continued overleaf

(54) Abstract Title
Fabric reinforced retroreflective assembly

(57) A retroreflective assembly includes a fabric substrate 2 at least partially impregnated with an adhesive 3, with retroreflective elements such as glass beads 4 partially embedded in the adhesive 3. The embedded part maybe metallised, or the adhesive may include reflective platlets. A light transmissive top cover 5 is joined to the substrate 3 by a number of narrow bonds 6,7 which divide the space between the substrate 3 and top cover 5 into a number of cells in which the glass beads 4 have an air interface. A barrier film 8 is joined to the opposite side of the substrate 2 to the top cover 7 to ensure that the substrate 2 is impermeable.

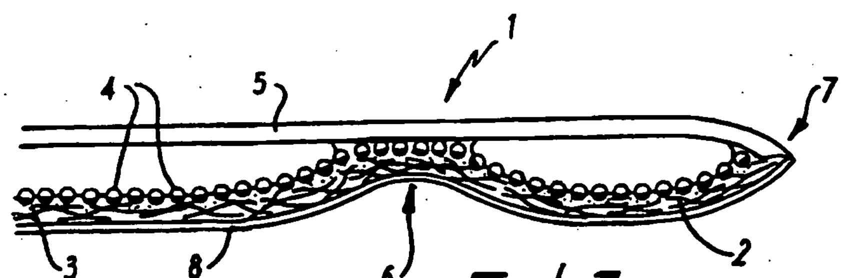

FIG. 1

GB 2 339 711

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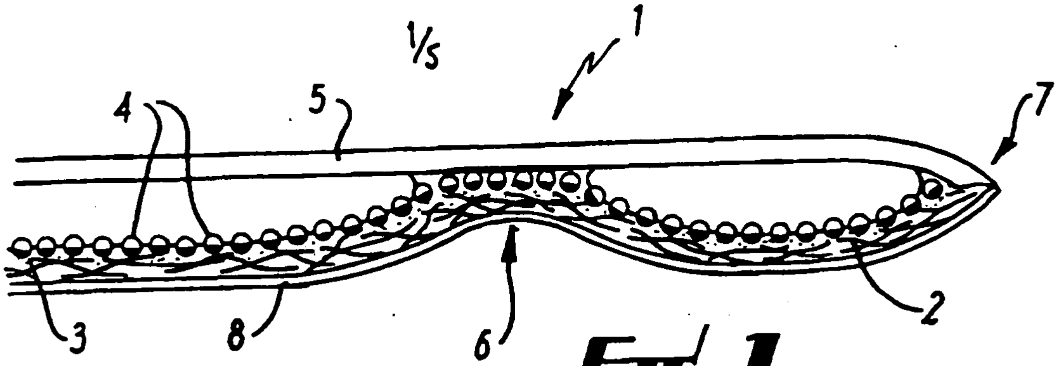


FIG. 1

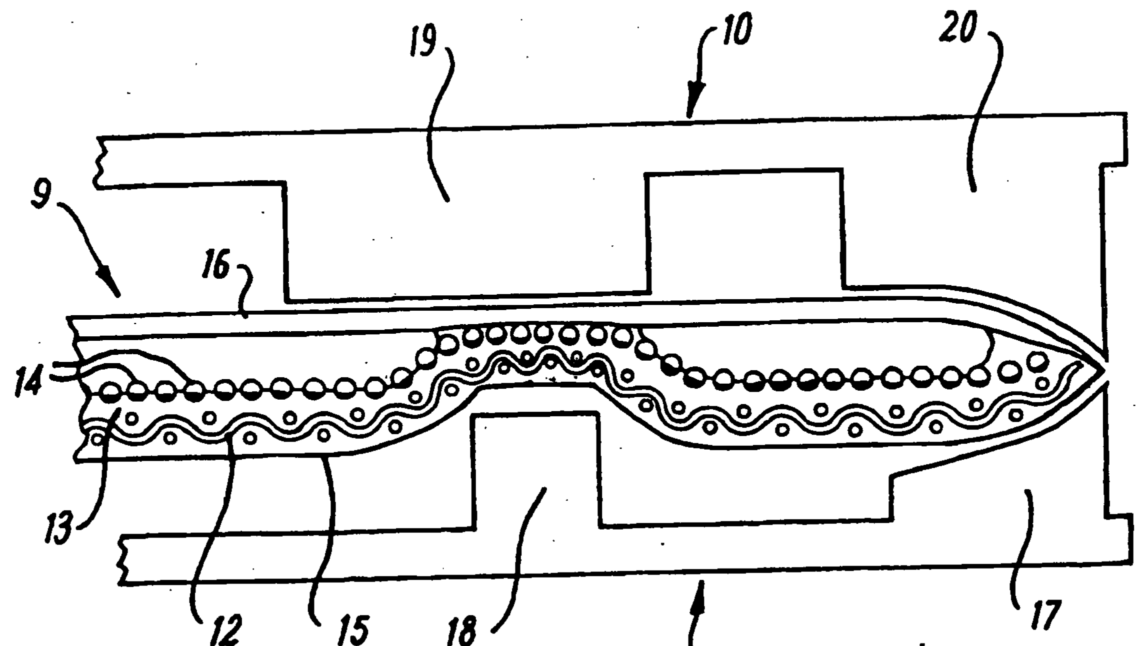
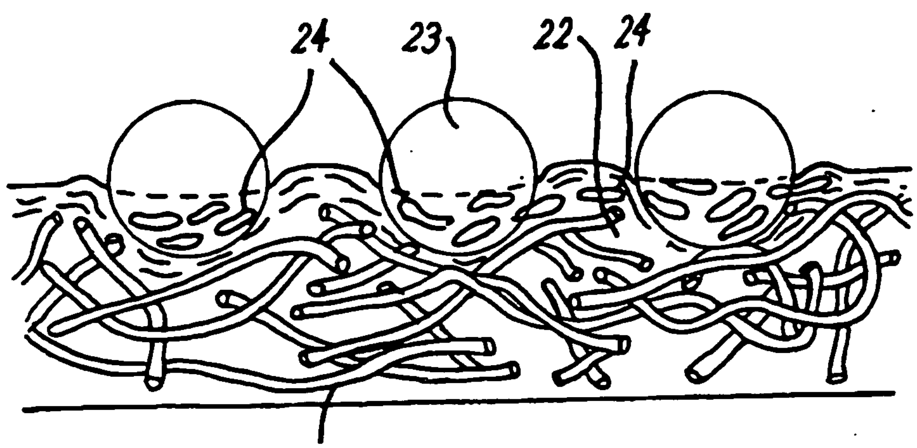


FIG. 2



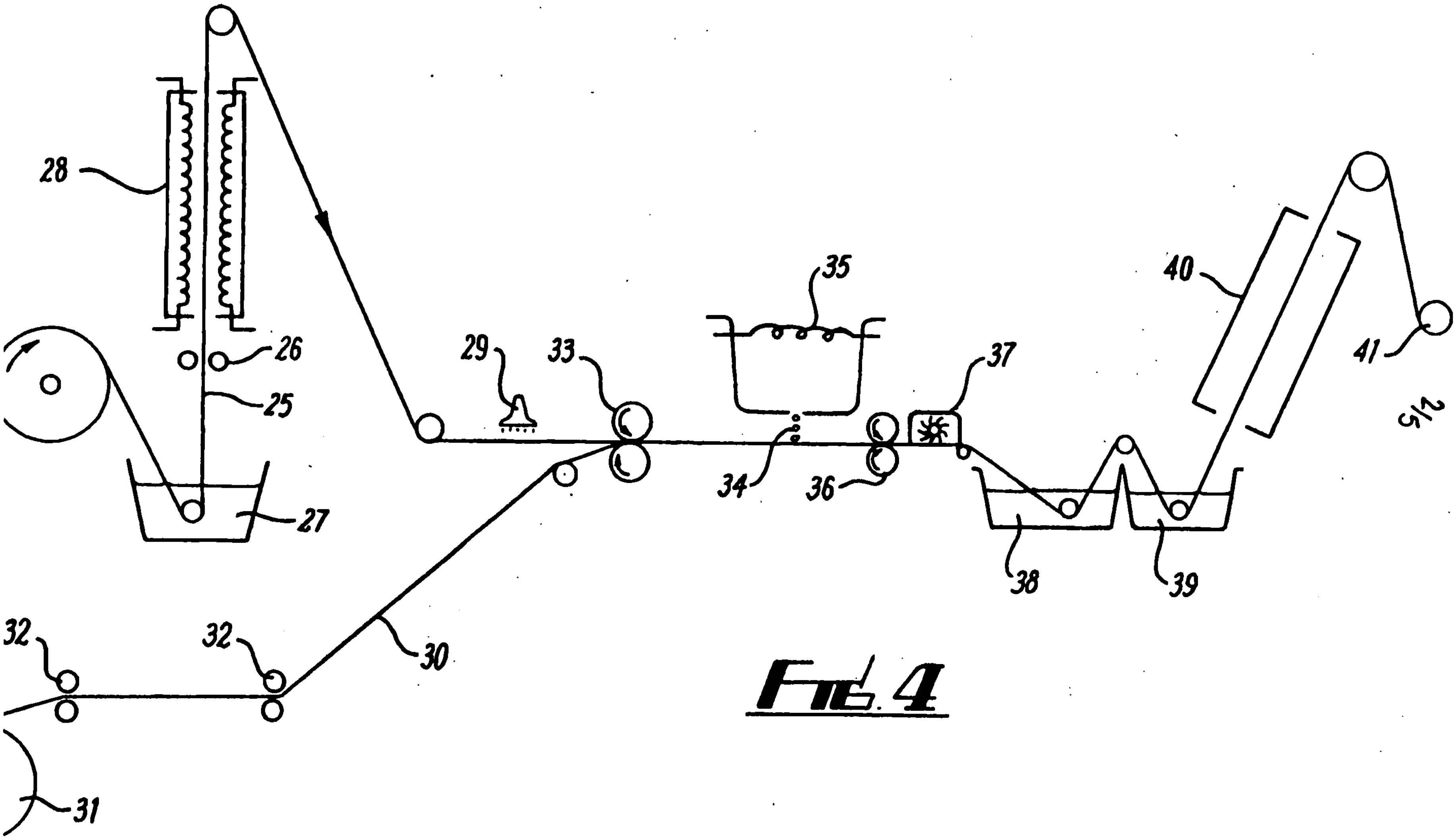


FIG. 4

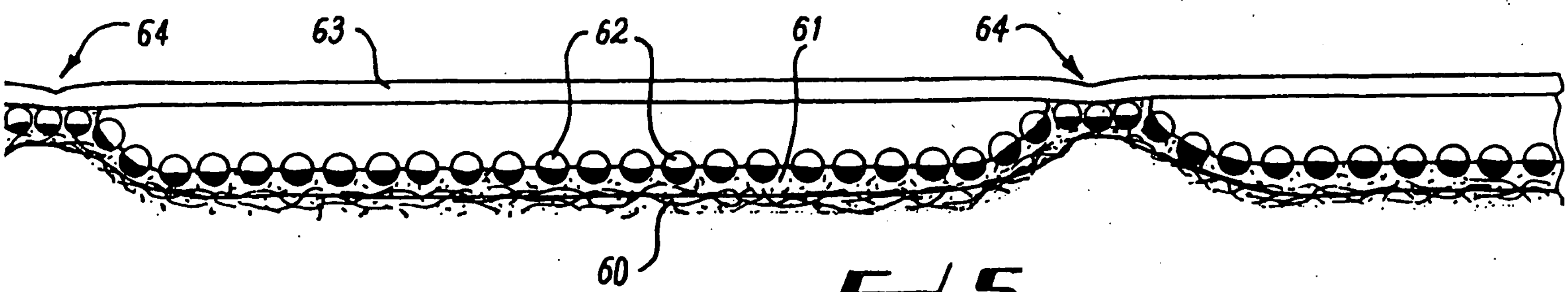


FIG. 5

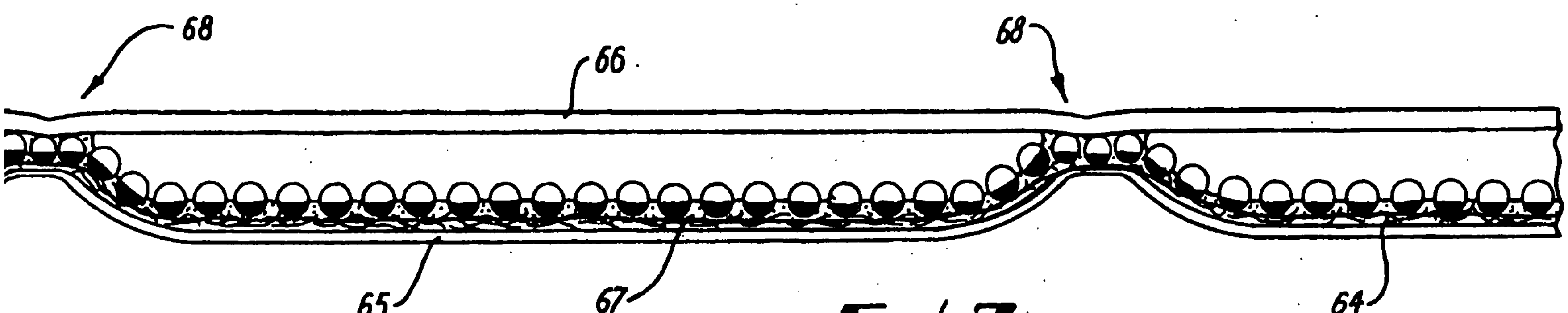


FIG. 7

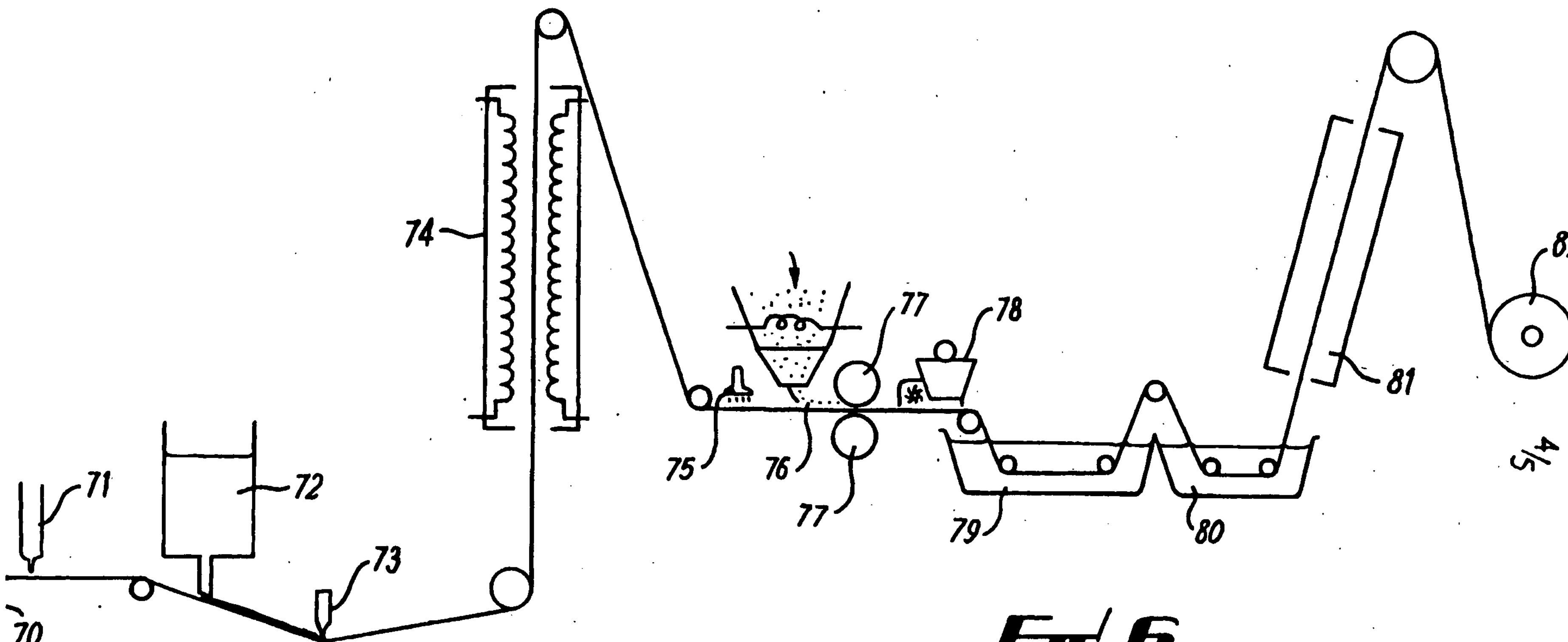


FIG. 6

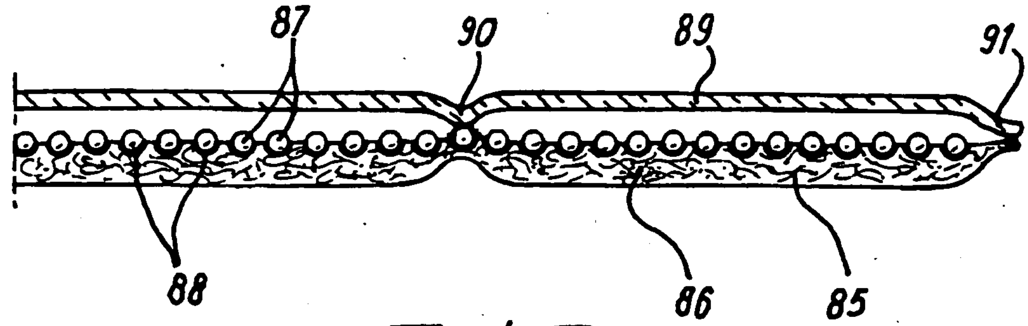


FIG. 8

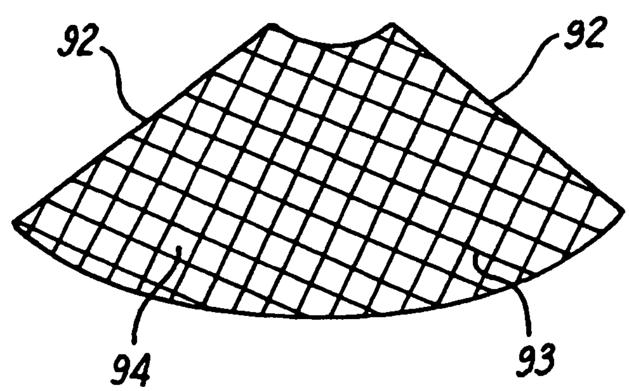


FIG. 9

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FABRIC REINFORCED RETROREFLECTIVE ASSEMBLY

This invention relates to a fabric reinforced retroreflective assembly and a method for the manufacture thereof.

Retroreflective materials are well known and are used in diverse applications including road safety products, personal safety equipment, fashion and sporting goods, footwear, vehicle identification, marine, aviation and metrology.

US Patent No. 3190178 (McKenzie) describes a retroreflective sheet material which comprises a plastics base sheet including a binder material, a monolayer of glass microspheres partially embedded in and partially exposed above the base sheet with a specular reflective metal layer underlying the embedded surfaces of the microspheres, a transparent cover film spaced above the layer of microspheres and a lattice network of narrow intersecting polymer based bonds that extend over the surface of the base sheet to adhere the base sheet and cover film together and divide the space between the base sheet and cover film into hermetically sealed cells or pockets in which the microspheres have an air interface.

The bonds are formed by displacing the binder material from the base sheet into contact with the cover film, using heat and pressure. A base sheet and cover film are inserted between a pair of heated metal platens one of which is an embossing platen having a pattern of raised ridges. The ridges of the embossing platen press against and deform the base sheet.

The binder material is heated and pressed sufficiently so that it floods the microspheres in the area pressed and contacts the cover film. The pattern of ridges is such as to form the desired network of narrow bonds.

US Patent No. 4025159 (McGrath) teaches an improved material to McKenzie wherein the lattice network of polymer based bonds are, after their thermoplastic phase, cured *in situ* to give an improved resistance to delamination of the cover film.

A problem with the use of externally applied heat and pressure to join the base sheet and cover film is that of layer thinning along the cell wall pattern. This is caused by the displacement of the binder, and possibly other, material from the join site when heat and pressure are applied.

In practice these materials rely on the binder material being deformable or flowable in its thermoplastic phase at a much lower temperature than, particularly, the cover film. Thus platens, dies or calendar rollers which are hot enough to flow the binder material whilst not degrading or materially affecting the cover film are usually used. Indeed, much use of these techniques has been made in relation to materials employing stiff top covers such as polyesters, acrylics and polycarbonates formulated to have a much higher melting temperature than the binder or base layer which typically melts and flows in the 50 to 150°C range. A problem in choosing higher melting temperature harder cover film materials to make these products is that they require physical cutting such as by die

cutting on clicking presses or slitting machines. They cannot usually be heat cut, for instance by the use of hot blades.

UK Patent No. 2255044 describes how a similar material to those described in US 3190178 and 4025159 can be made without the use of external heat. In this case the heat used to flow the binder material to the top cover is generated inside the assembly through the use of radio frequency (R.F.) energy. This has proven to be of great practical use where softer lower melting point polymers are employed, such as plasticised PVC and polyurethane. As heat is generated inside the assembly it does not have to pass through the material from an external source. The join or weld achieved between the base sheet and cover film is therefore confined largely to the inner faces of these layers, their outer faces are left largely unaffected by heat. Nevertheless, in practice there is usually some displacement of material from the inner faces of the layers and the problem of layer thinning still occurs.

For example, in an assembly made up of a plasticised PVC or polyurethane base layer and a plasticised PVC top cover where each of the top cover and base layer is 150μm thick the inner face of each layer may be squeezed sideways at join sites such that 50μm of each is displaced, reducing the overall laminate thickness by 100μm, or 30% of its original thickness, with a commensurate reduction in tear strength.

Where it is desired to make the same assembly using external heat

and pressure the problem is even greater. It is necessary to heat the outer face of either or both the cover film and base sheet sufficient to cause the binder material to become thermoplastic. In the case of plasticised PVC layers in particular the PVC may well be raised to its own softening point, in which case the platen or die is likely to press right through the whole assembly.

Another problem with existing microsphere based retroreflective materials is that, as good retroreflective performance requires that the extent to which the microspheres are embedded is carefully controlled, it is necessary that the thickness of any binder layer applied to a substrat is carefully controlled during manufacture. This is inconvenient.

It was with these, and other, problems in mind that the present invention was made.

According to a first aspect of the present invention there is provided a retroreflective assembly comprising a fabric substrate, an adhesive on the fabric substrate and some elements suitable for retroreflective purposes partially embedded in the adhesive.

According to a second aspect of the present invention there is provided a method of manufacture of a retroreflective assembly comprising the steps of providing a fabric substrate, applying an adhesive to the fabric substrate and partially embedding some elements suitable for retroreflective purposes in the adhesive.

The provision of a fabric substrate leads to a significant reduction in the problem of layer thinning when joining the assembly to another structure. This is due to the tendency of the fabric to restrict the flow of molten adhesive away from a join site.

The fabric is preferably at least partially impregnated with the adhesive. The adhesive is preferably heat reactivable.

The assembly preferably also comprises a single or multilayer light transmissive top cover spaced above the retroreflective elements. The top cover is preferably joined to the substrate by narrow bonds which divide the space between the substrate and cover film into hermetically sealed cells in which the retroreflective elements have an air interface. It is therefore desirable that the adhesive renders the fabric substantially impermeable. The cells could be formed by a network of narrow intersecting or another suitable pattern of bonds, for example discrete circles. The bonds are preferably formed by the adhesive, using any suitable technique, for example by the application of external heat and pressure, or internally generated heat plus pressure, the heat being generated by either R.F. or ultrasonic radiation.

To enable R.F. radiation to be employed it is clearly necessary for at least one of the components of the assembly to be R.F. responsive, although it is preferable that the fabric is not R.F. responsive.

It is preferred that the fabric is formed from a thermoplastic material

to enable the assembly to be heat cut if required, but that the fabric does not break down during joining of the substrate and top cover. As such the melting temperature of the fabric is preferably higher than the activation temperature of the adhesive. More preferably the softening temperature of the fabric is higher than the activation temperature of the adhesive. Still more preferably the softening temperature of the fabric is higher than the melting temperature of the adhesive, particularly at least 20°C higher. The melting temperature, more preferably the softening temperature, of the fabric is preferably higher than that of any other layer present in the assembly, for example a top cover.

For the avoidance of doubt, as used herein, activation temperature is defined as the lowest temperature of the activation temperature range of the adhesive.

The fabric preferably comprises a non-woven fabric. Non-woven fabrics are more effective at restricting the flow of adhesive from a join site than woven fabrics, they are also usually of lower cost. Heat bonded non-woven fabrics are preferred adhesive bonded types. Two or more layers of fabric could be used to form the substrate, including a combination of different fabric types.

Suitable fabrics include any of polypropylenes, polyethylenes, polyamides (nylon), polyesters, polythenes and acrylics. They are preferably of thickness in the range 50 to 500μm, more preferably 50 to 300μm and

particularly 100 to 250μm when uncoated with adhesive. Their mass is preferably in the range 5 to 150g/m^2, more preferably 5 to 75g/m^2 and still more preferably 10 to 35g/m^2. Preferred individual filament diameters are below 200μm, more preferably below 100μm and still more preferably between 5 and 40μm. The individual filament lengths are preferably as long as possible, average lengths of greater than 2cm being particularly useful.

Polypropylene fabrics are preferred. Preferably they have a melting temperature in the range of 120 to 180°C, more preferably 140 to 170°C and particularly about 165°C. Preferred filament diameters for these fabrics are between 15 and 25μm and more preferably about 20μm.

Nylons and polyesters normally provide a stiffer fabric material than polypropylene and for these materials a finer filament diameter is preferred, between 5 and 20μm, optimally between 12 and 20μm and particularly about 17μm. These materials typically have a higher melting temperature than polypropylene. Preferred nylon and polyester fabrics have a melting temperature in the range 190 to 255°C. Nylon and polyester fabrics allow adhesives with higher activation temperatures to be used than polypropylene fabrics.

The activation temperature of the adhesive is preferably in the range 100 to 120°C. Suitable adhesives include any of polyurethanes, acrylics, combinations of polyester and acrylic resins, styrene and acrylate. The adhesive may have a crosslinked phase after its thermoplastic phase.

The elements suitable for retroreflection may comprise optical glass or polymer microspheres and/or microprisms. Glass microspheres are preferred. They preferably have a diameter in the range 40 to 150μm, more preferably 50 to 85μm. They are preferably coated all over with a reflective material, for example a metal, and once partially embedded in the adhesiv the coating on the exposed part of the microspheres removed.

The method of manufacture preferably includes the step of providing a water or other solvent based adhesive, for example an aqueous polymer dispersion, applying this to the fabric substrate and then causing it to dry. Alternatively the adhesive could be applied as a molten polymer and then allowed to set. The adhesive may be subsequently reactivated by heating to enable the elements suitable for retroreflection to be embedded therein. The elements may be heated prior to being embedded.

In one embodiment the adhesive is presented on opposite sides respectively of the fabric. In another embodiment the adhesive is disposed to present an adhesive surface on one side only of the fabric.

To produce the first mentioned embodiment it is necessary to completely impregnate, or coat both sides of, the fabric with adhesive. This can be achieved by running the fabric through a bath of adhesive or by coating one side of the fabric with sufficient adhesive so that it penetrates its entire thickness. Where adhesive is presented on both sides of the fabric this overcomes a problem associated with existing materials where a binder

layer is applied to one side only of an impermeable plastics substrate. In this case the exposed side of the substrate of the completed assembly does not have adhesive properties and difficulties are encountered where it is desi ed to attach the material to a support or to itself to form a sleeve, for example for a traffic cone. It is necessary to either apply an adhesive to the material or, where appropriate, to use R.F. welding, both of which could be expensive or inconvenient. However, with the present invention where adhesive is present on both sides of the fabric substrate this can simply be activated with direct heat allowing a bar weld to be formed without the need for R.F. welding. The exposed side of the substrate could be covered with a release paper or other solid underlayer.

The second mentioned embodiment may be produced by applying adhesive to one side only of the fabric. An advantage of this embodiment is that less adhesive is required, resulting in more economic manufacture. There are also no problems with adhesive being exposed to the outside of a completed assembly with a top cover, where this is not required. The completed assembly has a non-tacky back surface and can therefore be conveniently rolled.

The type of fabric, adhesive and the manner in which it is applied can affect the manner and extent to which the fabric becomes coated or impregnated with adhesive and the properties of the resulting assembly. Where the adhesive is provided in a water based form different

characteristics are achieved by the use of fabrics composed of hydrophilic or hydrophobic materials. Polymers that have a surface energy of about 35-36 dynes or higher, for example polyester, are generally termed hydrophilic. It is normally possible to coat such polymers with a water based liquid. Polymers that have a surface energy below about 35-36 dynes, for example polymers from the polyolefin family, particularly polypropylene and polyethylene, are generally termed hydrophobic and repel water. Water based liquids do not normally easily wet out the surface of these polymers.

The characteristics of both polymers and water based liquids can be altered by addition of additives and by other processes.

Where it is desired to produce an assembly with adhesive presented on opposite sides respectively of the fabric using a water based adhesiv it is preferable to use a hydrophilic fabric, for example a polyester fabric. These fabrics readily wick up the water based adhesive and hence are easily saturated and reliably rendered impermeable when the adhesive dries. For example it is possible to load a 30g/m^2 non-woven polyester fabric of nominal thickness 220 microns with as much as 200g/m^2 of wet material which, if it has a 45% solids content, will give an end dried result with 90g/m^2 of adhesive.

As used herein the term hydrophilic fabric means a fabric with a surface energy sufficiently high so that it will absorb a chosen water based adhesive.

In contrast, where it is desired to produce an assembly with adhesive presented on one side only of the fabric substrate using a water based adhesive it is preferable to use a hydrophobic fabric, for example a polypropylene or polyethylene fabric. As these fabrics do not readily absorb water based liquids it is necessary to physically urge the adhesive into the structure. Knife over air application techniques are preferred. The blade angle may be tailored to urge in a desired amount of adhesive. As there is no tendency for the adhesive to wick through the fabric, it may be applied to the fabric by flood coating one side.

As used herein the term hydrophobic fabric means a fabric with a surface energy sufficiently low so that it will not readily absorb a chosen water based adhesive.

This approach enables assemblies to be conveniently produced with adhesive presented on one side only of the fabric. Whatever coat weight of adhesive is applied it stays preferentially at the applied side of the fabric. However, the adhesive does not readily wet the surfaces of the fibres forming the fabric. It is mainly retained by the fibre structure rather than by adhesion. The adhesion of the adhesive to the fabric is imperfect. There is therefore a greater tendency towards pinholing of the adhesive when set. This is undesirable as it renders the adhesive coat d fabric substrate permeable.

This problem can be addressed by using more than one knife blade

to urge more adhesive into the fabric, but a preferred solution is for the fabric substrate to include hydrophilic and hydrophobic fibres presented on opposite sides respectively.

One example is made by providing a hydrophobic fabric and modifying the surface energy characteristics on one side only. For example by corona arc discharge, plasma, or gas fluorination treatment. Corona arc discharge treatment is preferred. By careful control of the treatment it is possible to control the depth from the surface of the fabric to which its surface energy is altered. Thus, it is possible to create a fabric that has one side with a tendency to readily wick up and wet out with a water based adhesive and the opposite side of which has a tendency to resist wetting out.

Polyethylene and polypropylene fabrics are particularly suited to this treatment. Once treated, the fabric can be flood coated with adhesive from one side without total saturation but with improved elimination of pinholing, over untreated fabrics.

For polypropylene fabrics of mass about 30g/m^2 and thickness about 20C,/m it is found that corona arc discharge treating the fabric on one side only by applying about 1500J/m^2 of energy alters the wetting out characteristics of the fabric from hydrophobic to hydrophilic to about 50% of its depth. When the fabric is flood coated with adhesive, the adhesive penetrates to no more than about 75% of its depth. The back surface

remains dry. If more energy is applied to the fabric a greater depth of the fabric is affected. Application of about $3000J/m^2$ alters the wetting out characteristics throughout almost all of the fabric's depth. The application of about $6000J/m^2$ alters the wetting out characteristics of the entire depth of the fabric. If less energy is applied to the fabric then a lesser depth of the fabric is affected. The application of about $900J/m^2$ alters the wetting out characteristics of the fabric to about 20% of its depth. When the fabric is flood coated with adhesive, this penetrates to about 40% of its depth.

The fabric is effectively self metering, in contrast to conventional film substrates where care is required to provide a desired thickness of adhesive coating.

Preferably, the fabric is impregnated to a depth of less than $100\mu m$, more preferably a depth about as great as that to which the retroreflective elements are to be embedded. For example, if beads of diameter $60\mu m$ are used the fabric is preferably impregnated with adhesive to a depth of at least $30\mu m$.

Another example is made by providing a hydrophilic fabric, loading it with a desired quantity of adhesive, backing it with a hydrophobic fabric and squeezing the two fabrics together in nip rollers, whilst wet, so that some adhesive is forced into the hydrophobic fabric, to bond the two fabrics together. The inclusion of the hydrophilic fabric allows a reliably impermeable assembly to be produced, while the hydrophobic fabric ensures

that one side remains tack free. Each fabric may be of lighter weight than is required when a single fabric is used. Hence, the amount of adhesive required to saturate the hydrophilic fabric layer is less than if a single layer of such fabric is used.

Ideally, impregnation of the fabric renders it impermeable so that when a top cover is bonded to the substrate hermetically sealed cells can be formed. It has been found, however, that even with hydrophilic fabrics small holes can develop in the adhesive when it is allowed to dry or set. This pinholing is undesirable as it allows water to pass through the fabric. If water comes into contact with retroreflective elements disposed on the fabric, under a top cover, it can impair retroreflective performance.

One mechanism by which pinholing is produced is thought to be through air entrapment in the adhesive. Small air bubbles then become entrapped in the fabric structure. When dry, the adhesive at the location of an air bubble is only present as a very thin skin. This skin may well collapse whilst drying, leaving a pinhole. Even if the skin survives it is likely to be so weak that even minor stress or further processing of the assembly results in tearing of the skin, again forming a pinhole.

Pinholing and other damage can also be caused to assemblies by tearing of the adhesive layer immediately adjacent to either a cell wall or edge weld as a result of application and/or removal of a welding tool when welding the substrate to a top cover. The result is clearly observable at slits

or pinholes close to the edge of the weld. A possible contributor to this problem is the inherent springiness of the fabric substrate which is heavily compressed during welding. This can put the adhesive surrounding weld sites under considerable stress.

One way in which this problem can be reduced is by providing a barrier film on the opposite side of the substrate to that on which the retroreflective elements are disposed, in order to render the substrate impermeable. This overcomes the problems caused by both air entrapment and tearing during welding.

The barrier film preferably comprises a flexible plastic film, for example of PVC. The film is preferably less than 60, more preferably less than 35 and still more preferably about 10μm thick.

The barrier film preferably has a softening temperature higher than the activation temperature of the adhesive, more preferably higher than the melting point of the adhesive. Still more preferably, the melting temperature of the barrier film is higher than that of the adhesive.

Suitable materials include those of the Resinite brand names MMX, which is approximately 10μm thick, MXA, which is approximately 14 mic.ons thick and CONVERTER, which is less than 10μm thick. All three are highly deformable, have a melting point above 140°C, and do not exhibit significant loss of strength at temperatures in the 90°C to 120°C range, the activation temperature range of many holt melt/thermoplastic

heat activated adhesives. Such adhesives are suitable for use in the invention.

Elongation to break for these materials was found to be as high as three or even five times the original. It is preferable that the barrier film material has good elongation to break properties.

The barrier film is preferably bonded to the substrate, by way of the adhesive. The barrier film is therefore preferably applied to the substrate whilst the adhesive is at its activation temperature. This can conveniently be achieved by applying the barrier film before, after or during microsphere application, for which the adhesive would also require to be active. The film and substrate are preferably fed through nip rollers to join it to the adhesive coated fabric.

Alternatively the barrier film could be joined at the same time that a top cover is attached to the substrate. Even if the substrate is only partially impregnated with adhesive compression of the substrate along the cell wall pattern when attaching the top cover will urge sufficient adhesive through the substrate to bond it to the barrier film.

The barrier film could also be joined after a top cover has been attached to the assembly. The film could be appli d as a coating.

A tendency for PVC films to shrink when heated can be overcome by preheating the film after unwinding from a supply roll and allowing it to relax unoer minimum tension prior to feeding it through nip rollers to join it to the

adhesive coated fabric substrate.

As well as rendering the substrate impermeable, using a barrier film confers a number of other important benefits. By introducing even a very thin layer of PVC the ability to join a top cover to the substrate by using high frequency welding techniques is possible, even if the remainder of the assembly is not R.F. responsive. This would, for example, be the case for an assembly comprising a polypropylene fabric substrate coated with an acrylic adhesive to be attached to a clear polyester top cover. As the strength of PVC film is high compared to its thickness it is possible to reduce the thickness of the fabric substrate without impairing the strength of the finished assembly. For example, a $17g/m^2$ non woven polyester or polypropylene fabric substrate with a $10\mu m$ thick PVC barrier film secured thereto can be used in place of a $35g/m^2$ fabric without a barrier film. It is found that the cost of the barrier film is more than offset by the saving made by using lighter fabric. Using a lighter fabric also reduces the amount of adhesive required.

It will be realised that by having a barrier film disposed on what would form the exposed side of a completed assembly, including a top cover, no adhesive is presented on that surface. In another embodiment, therefore, a barrier film is sandwiched between two layers of fabric, both of which are impregnated with an adhesive. Typically, a $10\mu m$ thick barrier film is sandwiched between two $17g/m^2$ layers of impregnated fabric. This

allows the assembly to be attached to a surface, for example a garment, by either heat or R.F. welding. Of course, the exposed fabric layer could be impregnated with any suitable adhesive, for example a pressure sensitive adhesive, and may be provided with a release film. Where a PVC barrier film is used a plasticiser tolerant adhesive is preferred, for example a polyurethane based adhesive.

Another way in which the problem of pinholing may be reduced is by passing the adhesive coated fabric between rollers heated to a temperature sufficient to flow the adhesive. Flowing the adhesive once it has been applied to the fabric effectively fills any pinholes or voids that may be present. This approach is particularly effective in reducing pinholing du to air entrapment. The rollers are preferably heated to, at least, the activation temperature of the adhesive.

A further benefit with fabrics which remain hydrophobic on one side is realised if the fabric is immersed in a solution, for example the etching and washing solutions used to remove the exposed metal coating from certain retroreflective elements. Since these fabrics do not readily soak up water based solutions it is much easier to remove excess solution than with hydrophilic fabrics. This is important since most etching solutions are expensive and difficult to dispose of.

Incidentally, complete corona arc discharge treatment of a polyethylene or polypropylene fabric produces a completely hydrophilic

fabric which is more economic than polyester.

In another embodiment a pressure sensitive adhesive is used. The use of such an adhesive allows assemblies to be manufactured and joined to other structures at ambient temperature and hence overcomes the problems associated with the use of elevated temperatures, particularly that of layer thinning. It is also more economic and convenient than using elevated temperatures.

For the avoidance of doubt, as used herein, pressure sensitive adhesive is defined as an adhesive which remains tacky at ambient temperatures. It is preferred that the adhesive remains tacky in the temperature range 5 to 40°C.

Polymer based adhesives are preferred. For example, polyurethane based adhesives.

Joining of the substrate to the top cover may be effected by inserting a substrate and cover film between metal platens or rollers, at ambient temperature, one of which has a pattern of raised ridges corresponding to the desired bond pattern. The ridges may be pressed against either the fabric or top cover, bringing the adhesive into contact with the top cover. Since the adhesive remains tacky at ambient temperatures it will adhere the fabric to the top cover.

In order to increase the integrity of assemblies produced this way, and to reduce the risk of the fabric and top cover becoming separated, it is

preferred that once the substrate has been joined to the top cover and/or another structure the adhesive is cross-linked. This serves to strengthen the join. Any suitable cross-linking mechanism may be employed appropriate to the adhesive used.

Assemblies according to the invention offer considerable potential for cost saving, over conventional materials. For instance, a conventional 150µm PVC sheet coated with adhesive on one side, to rec ive retroreflective elements, can be replaced with a non-woven polypropylene fibre mesh available for approximately 10% of the cost of the PVC sheet. Also, by providing a fabric substrate, the overall thickness of the substrate can be reduced by as much as 60% compared to known PVC materials. As a result a quicker process time can be achieved when joining the substrate to a top cover since there is less material present to raise to softening or melting temperature and higher die temperatures can be used.

The savings achieved through using cheaper materials and through more efficient process time and temperature tolerance obtained by the use of a fabric substrate are of exceptional value in particular fields where profit margins achieved have been low, such as in sleeves for traffic cones, cylinders, bollards, and flexible signage, but are applicable to other fields such as marine safety retroreflective strips and patches, where margins are higher.

It has also been found, particularly where a non-woven fabric is used,

that the preferred combination of filament diameter, fabric weight and fabric thickness provides a much more tolerant substrate into which microspheres are to be embedded. The presence of the fibres in the adhesive greatly assists in preventing over embedding of the microspheres. It is well known that it is desirable to embed the microspheres to about half their diameter. Existing materials generally require very close tolerance and control to achieve this either by transfer carrier web techniques or by direct application of microspheres into a controlled thickness of binder layer on a substrate material. However, the multitude of thin filaments present in assemblies according to the invention resists over embedding of the microspheres even when the adhesive becomes readily flowable.

The relationship between microsphere diameter and filament diameter is important in obtaining this benefit. The preferred fabric characteristics for non-woven fabrics with microspheres in the 40 to 150μm diameter range are given in the following table.

	Mass (g/m^2)	Fabric thickness before coating (microns)	Filament dia (microns)
GENERAL ALL FABRICS	15 - 30	90 - 200	10 - 30
	20 - 40	100 - 400	10 - 30
	30 - 50	140 - 500	10 - 30

POLYPROPYLENE FABRICS	15 - 30	90 - 200	15 - 30
	20 - 40	100 - 280	15 - 30
	30 - 50	150 - 350	15 - 30
	17	about 120	about 20
	20	about 130	about 20
	30	about 170	about 20
	40	210 - 250	about 20
	50	220 - 300	about 20

It will also be appreciated that although particularly beneficial to the manufacture of soft flexible retroreflective materials, especially those employing plasticised PVC top covers, the benefits described will be available to hard faced or hard backed assemblies employing higher temperature resistant/stable polymers such as polyester films, polycarbonates acrylics and materials of similar thermal characteristics.

In order that the invention may be more clearly understood embodiments thereof will now be described by way of example, with reference to the accompanying drawings of which:-

Figure 1 is a cross-section through a first embodiment of a retroreflective assembly according to the invention;

Figure 2 is a cross-section through a second embodiment of a retroreflective assembly according to the invention, during manufacture;

Figure 3 is a cross-section through part of a third embodiment of a

retroreflective assembly according to the invention, shown at a larger scale than those of Figures 1 and 2;

Figure 4 is a schematic view of equipment for the manufacture of assemblies of the type illustrated in Figures 1 and 2;

Figure 5 is a cross-section through a fourth embodiment of a retroreflective assembly according to the invention;

Figure 6 is a schematic view of equipment for the manufacture of assemblies of the type illustrated in Figure 5;

Figure 7 is a cross-section through a fifth embodiment of a retroreflective assembly according to the invention;

Figure 8 is a cross-section through a sixth embodiment of a retroreflective assembly according to the invention; and

Figure 9 is a plan view of a retroreflective assembly of the type shown in Figure 8.

Referring to Figure 1, a first embodiment of a retroreflective assembly, generally 1, comprises a non-woven fabric substrate 2, impregnated with a polyurethane adhesive 3 in which some partially metallised optical glass microspheres 4 are partially embedded, the non-metallised part of each of which projects above the adhesive 3. A light transmissive PVC top cover 5 is joined to the substrate 2 to form a number of isolated pockets or cells. Join 6 is a cell wall join, separating two isolated cells in the assembly. Join 7 is an edge tear seal defining the edge

of the assembly 1. A 10μm thick PVC barrier film 8 is bonded to the opposite side of the substrate 2.

Fabric 2 has a mass of about 20g/m^2 a thickness of about 130μm (when uncoated) and is composed of polyester fibres with an average diameter in the range 15 to 25μm, an average filament (fibre) length in excess of 1cm and a melting point of about 250°C. The adhesive has an activation temperature of about 110°C and includes Titanium Dioxide (TiO_2) as a white pigment. The top cover 5 has a softening temperature of approximately 120°C.

The melting temperature of the fabric 2 is higher than the melting temperature of the top cover 5 and barrier film 8, and the activation temperature of the adhesive 3. It can therefore maintain its structure even when the adhesive 3, top cover 5 and barrier film 8 have been softened.

The microspheres 4 have an average diameter of between 56 and 75μm.

In an alternative embodiment a second layer of adhesive impregnated fabric is joined to the other side of the barrier film, so that the film is sandwiched between two fabric layers.

Referring to Figure 2 there is shown a second embodiment of a retroreflective assembly, generally 9, between heat d dies 10 and 11 used to join the layers of the assembly together. The retroreflective assembly 8 is similar to that illustrated in Figure 1, except in so far as it includes a

woven fabric substrate 12.

The fabric 12 is impregnated with an adhesive 13 in which there are partially embedded some partially metallised glass microspheres 14. A barrier film 15 lies adjacent the fabric 12.

Figure 2 shows the joining of the fabric 12 to a transparent top cover 16 using the heated dies. Although the use of dies is illustrated in relation to an assembly incorporating a woven fabric substrate 11 clearly it is app.icable to assemblies with non-woven fabric substrates such as that illustrated in Figure 1.

The transparent top cover 16 has a softening temperature of about 120°C. Adhesive 12 has an activation temperature of about 110°C and will wet out and adhere well to top cover 16 and barrier film 15 when softened to a flowable level. The fabric mesh 12 has a softening temperature range of 125 to 140°C. Upper die 10 is maintained at a temperature of up to 115°C, but not so low that it acts as a heat sink detrimental to the process. Lower die 11 is maintained at a temperature well above the melting point of adhesive 13 and a little above that of fabric 12, in this case about 145°C to 155°C.

Die piece 17 projects further than die piece 18 and therefore when the upper and lower dies are brought together die piece 17 will contact the material lay up before die piece 18. Die piece 17 will contact die piece 20, die pieces 18 and 19 will not touch.

In use, the dies are brought together so that die pieces 17 and 20 contact the layers of the assembly under just enough pressure to compress them together. Heat is transferred by contact from die piece 17 to adhesive 13. The temperature of adhesive 13 rises quickly to its softening temperature, whence it becomes flowable. This is time dependent but until some softening of the adhesive occurs die piece 17 will not sink significantly into the substrate. Consequently die piece 18 is held off the substrate or is in minimal contact and reduced pressure compared to die piece 17. Therefore the area of the lay-up between die pieces 17 and 20 will heat up more on equal time basis than the area between die pieces 18 and 19. The area between 17 and 20 will therefore reach the softening temperature of the fabric 12 before or at the same time as the area between 18 and 19 reaches only the activation temperature of the adhesive 12, at which it will flow and join with top cover 14. Thus the materials will b joined and cut between 17 and 20, but only joined between 18 and 19.

It will be understood from this that the integrity and strength of the material at the cell wall formed between 18 and 19 remains largely unimpaired due to the retention of the fabric component 12 in tact in the adhesive 13.

In addition it is found that the presence of the fabric 12 has a modifying effect on the nature of the flow of the adhesive 13. For example, in the absence of any fabric the adhesive 13, once at a flowable

temperature, would preferentially flow sideways under die pressure, especially at the interface with the die pieces 18 and 19. The adhesive next to die piece 18 would flow earlier than the adhesive 13 next to the top cover 16 because of the direction of heat flow. The result would be excessive thinning of the adhesive before the adhesive adjacent to the top cover 16 became hot enough to flow and join with the top cover 16. Whereas, with the present invention the fabric layer 13 tends to impede or restrict the sideways flow of adhesive 13 so that much less thinning occurs. Because the hot adhesive 13 is held longer in place heat is more quickly transferred to the adhesive 13 adjacent the top cover 16 enabling a join to the top cover 16 to be better and more quickly effected. This, in turn, allows a much thinner layer of adhesive to be employed than would otherwise be the case and leads to a further cost and time saving due to a reduction of material required to be heated. Higher die temperatures can be employed than could be tolerated without the fabric 12 being present, again leading to shorter joining times and further efficiencies. The process becomes altogether more temperature tolerant and easier to accomplish whilst retaining or realising the ability to achieve a heat seal and heat cut at the outer edge of a product of a desired shape.

Referring to Figure 3, a third embodiment of the invention includes a non-woven fabric substrate 21, impregnated with an adhesive 22 partially embedded in which are some glass microspheres 23. Included in the

adhesive is some reflective material, comprising aluminium platelets 24. A top cover may be attached to the fabric 21, over the glass microspheres 23, as described above. This embodiment is essentially similar to that shown in Figure 1 except that, because it employs reflective material in the adhesive 22, it is not necessary for the microspheres 23 to be metallised. This reduces the cost of production of the material. Although assemblies employing an adhesive or binder layer containing reflective material are known the embodiment illustrated in Figure 3 conveys significant advantages. During assembly reflective material is dispersed in fluid adhesive which is then applied to the fabric 21. If the adhesive is applied to one side only of the fabric it acts as a filter and the reflective material is concentrated on one surface only. This concentration of reflective material leads to improved retroreflective performance.

Referring to Figure 4 the assemblies illustrated in Figures 1 and 2 are produced as follows. A fabric substrate 25 is dispensed from a roll. The fabric 25 passes through a bath of a water based polyurethane dispersion adhesive 27 having a solids content of 40-50% to impregnate the fabric 25 so that voids between fibres are substantially filled. A suitable adhesive is a mixture of 90% Neo Res R560 (a polyurethane adhesive) and 10% Neo Cryl 1052 (an acrylic adhesive) manufactured by Zeneca PLC and supplied by Elliss Everard in the U.K.. The hydrophilic polyester fabric readily absorbs the adhesive. Excess adhesive is then removed by passing the,

now saturated, fabric 25 through rollers 26, which also help to ensure that the fabric 25 is fully saturated.

Other adhesive application techniques could be used, for example flooding one side of the fabric and the use of a blade or roller and blade combination to remove excess adhesive.

The adhesive impregnated fabric is then passed through a vertical drying oven 28 to evaporate the water in the adhesive 27 to bring it to its thermoplastic phase. The adhesive impregnated fabric is then passed under a heater 29 to bring the adhesive to its activation temperature of about 110°C. A PVC film 30 is also dispensed from a roll 31, through guide rollers 32 arranged to allow the film to 'relax' to avoid shrinkage, and brought into association with the impregnated fabric 25. The fabric and film are then pressed together between nip rollers 33 to bond the film to the fabric.

Silver coated glass microspheres 34 with an average diameter in the range 56 to 75μm and refractive index in the range 1.91 - 1.93 which have been pre-heated with a heater 35 to above 200°C are then applied to the adhesive impregnated fabric 25. Heating the microspheres helps them to more easily penetrate and bond with the adhesive.

The fabric is then passed between heated nip rollers 36 to press the microspheres 29 into the adhesive on the fabric so that they become partially embedded in and firmly adhered to the fabric, to about 45 % of their

diameter.

Excess microspheres are removed by way of a vacuum and brush assembly 37, any other suitable means could be used. The silver coating on the exposed part of the beads is then removed by conventional means. The fabric is passed through an etching solution 38 to remove the silver, washed in water or an appropriate solution 39 and passed through a dryer 40. The finished product is then stored on a roll 41 before attachment of a top cover, as shown in Figure 2, or use in other application.

Although the equipment illustrated in Figure 4 and accompanying method is described in relation to the embodiments illustrated in Figures 1 and 2 it can also be applied to the production of the assembly illustrated in Figure 3, except that the etching stage need not be included as metallised beads are not required. However, as disclosed above, when producing an assembly of the type illustrated in Figure 3 it is preferable to apply the adhesive, containing reflective material, to one side of the fabric only, to maximise the concentration of reflective material underlying the beads.

Referring to Figure 5, a fourth embodiment comprises a non-woven polypropylene heat bonded fabric 60. The fabric 60 is composed of polypropylene fibres with an average diameter of about 20μm and average filament length greater than 2cm. The uncompressed thickness of the fabric is about 170μm and its dry (uncoated) mass about 30 g/m^2. The fabric has softening and melting temperatures of about 153 and 165°C respectively.

A suitable fabric is that sold under the name T402 by Lantor (UK) Ltd.

The fabric 60 is partially impregnated to about half its thickness with an acrylic adhesive 61. The adhesive has an activation temperature of approximately 100°C.

Partially embedded in the adhesive are some partially metallised glass microspheres 62, the non-metallised part of which projects above the surface of the adhesive. They have a diameter between 63 and 78 microns and a refractive index between 1.91 and 1.92.

Bonded to the fabric 60, by way of the adhesive 61, is a light transmissible PVC top cover 63. The top cover 63 and fabric 60 are joined by a number of bonds 64 to form isolated pockets. Away from the bonds the top cover 63 is spaced above the microspheres 62. The top cover is formed by a plasticised clear PVC film about 200 microns thick with softening and melting temperatures of about 120 and 165°C respectively. Any suitable technique to reactivate the adhesive 61, and effect the bond may be used, for example external heat and pressure or R.F. welding. Exertion of pressure at the bond sites 64 results in the adhesive 61 being squeezed through the fabric 60, so that there is a greater degree of impregnation at these points.

In an alternative embodiment a clear polyester top cover could be used. A suitable material having a melting point about 200°C and a thickness of about 60 microns.

Referring to Figure 6, the assembly shown in Figure 5 is produced as follows: untreated polypropylene fabric 70 of mass about $30g/m^2$ and thickness about $170\mu m$ is treated on one side only with corona arc discharge equipment 71 to apply about $1500J/m^2$ energy before being coated with an acrylic water based dispersion reactivitable thermoplastic adhesive 72 using a knife over air technique. Adhesive 72 is applied to the top surface of the fabric 70 which then passes under a blade 73. A suitable adhesive dispersion is that supplied under the name PR-11-34 by Industrial Latex Limited of England. The adhesive includes about 40% solids in w t form.

The untreated polypropylene fabric 70 is hydrophobic. The corona arc discharge treatment is arranged to render approximately half the depth of the fabric 70 hydrophilic. The water based adhesive is therefore wicked into the hydrophilic portion of the fabric and repelled by the hydrophobic part, resulting in partial impregnation of the fabric. In operation, a bead of adhesive forms along the edge of the knife 73, ensuring effective wetting of the fabric 70 with adhesive 72.

The adhesive is applied at the rate of about $100g/m^2$.

The fabric then proceeds through a vertical oven 74 to dry the adhesive. Once the water is driven off, the dried mass of adhesive is about $40g/m^2$.

The fabric 70 is then passed under a heater 75 to heat the dried

adhesive to its activation temperature. Preheated microspheres 76, coated all over with silver, are then applied to the fabric 70 which then passes between nip rollers 77 heated to about 145°C. The beads are embedded into the adhesive to approximately half their depth. Excess beads are then removed using brush and vacuum equipment 78.

Finally, the silver coating is removed from the exposed part of the beads and the coated fabric washed and dried, stages 79, 80 and 81 respectively. The completed fabric is then stored on a roll 82 ready for application of a top cover, or for some other use.

Referring to Figure 7 there is shown a further embodiment. This embodiment is similar to that shown in Figure 5 except that the fabric 64 is of mass about $17 g/m^2$. This is made possible by the provision of a $10 \mu m$ thick PVC barrier film 65 joined to the opposite side of the fabric 64 to which a top cover 66 is joined. The barrier film 65 and top cover 66 are joined to the fabric 64 in the same operation. Although the fabric 64 is only partially impregnated with adhesive 67, compression of the fabric 64 at join sites 68 during attachment of the barrier film 65 and top cover 66 results in adhesive 67 being forced throughout the thickness of the fabric 64. The adhesive is thus presented on opposite sides respectively of the fabric 64 to bond both the top cover 66 and barrier film 65.

Figures 8 and 9 show a further embodiment. Referring to Figure 8 the assembly comprises a non-woven polyester fabric substrate 85,

impregnated with a polyurethane based pressure sensitive adhesive 86.

Glass microspheres are partially embedded in the adhesive. The embedded surface of the microspheres are coated with a reflective material 88.

A light transmissive flexible PVC top cover 89 is secured to the substrate 85 by way of the adhesive 86 by a number of narrow intersecting bonds which divide the space between the substrate and top cover into a number of sealed cells or pockets. Bond 90 is a cell wall join, bond 91 forms the edge of the assembly.

A suitable adhesive is a polyurethane based pressure sensitive adhesive such as that supplied under reference number 280/47 by Baxenden Chemical, England.

The adhesive is applied to the substrate as a coating, at ambient temperature. Under these conditions the adhesive remains tacky, its so-called "green" state. Glass microspheres, coated all over with a metal reflective layer, are applied to the adhesive coated surface, excess beads removed and the remaining beads partially embedded into the adhesive by feeding the substrate between nip rollers. The metal coating on the exposed parts of the beads is then removed by etching.

Subsequently, a top cover is placed over the beads and the top cover and substrate fed between patterned rollers to urge the two together at sites where they are to be joined. This causes the adhesive to come into

contact with the top cover. Subsequently, the adhesive is cross-linked using an isocyanate process, upon which the adhesive is no longer tacky.

When completed the assembly can be cut using a guillotine, hot knife or other suitable technique, to the desired shape.

The fabric substrate may be saturated with adhesive so that adhesive is presented on both sides of the fabric. Where this is the case then adhesive is presented to the outside of the completed assembly. This enables an assembly to be secured to a surface or support. Alternatively, where a plastics sheet substrate is used adhesive could be applied to the outside surface.

Referring to Figure 9, there is shown a plan view of a portion of a retroreflective assembly similar in type to that shown in Figure 8, which may be used to form a road cone sleeve by joining it to itself along edges 92. The top cover is secured to the substrate by a series of narrow intersecting bonds 93. These form a lattice pattern which defines a number of sealed cells 94 between the layers.

Retroreflective assemblies according to the present invention convey numerous advantages. They are both more economic and easy to manufacture than existing assemblies by virtue of the replacement of a conventional impermeable substrate with a fabric which reinforces the structure, prevents over embedding of the retroreflective elements, and reduces the risk of the assembly being accidentally cut through or

weakened during manufacture, whilst still allowing the assembly to be heat cut where required.

The above embodiments are described by way of example only, many variations are possible without departing from the invention.

CLAIMS

1. A retroreflective assembly comprising a fabric substrate, an adhesive on the fabric substrate and some elements suitable for retroreflective purposes partially embedded in the adhesive.

2. An assembly as claimed in claim 1, wherein the fabric is at least partially impregnated with the adhesive.

3. An assembly as claimed in either claim 1 or 2 further comprising a light transmissive top cover spaced above elements suitable for retroreflective purposes.

4. An assembly as claimed in claim 3, wherein the top cover is joined to the fabric by narrow bonds which divide the space between the fabric substrate and cover film into cells in which the elements suitable for retroreflective purposes have an air interface.

5. A retroreflective assembly as claimed in any preceding claim, wherein the fabric is formed from a thermoplastic material.

6. A retroreflective assembly as claimed in any preceding claim, wherein the melting temperature of the fabric is higher than the activation temperature of the adhesive.

7. A retror flective assembly as claimed in claim 6, wherein the softening temperature of the fabric is higher than the activation temperature of the adhesive.

8. A retroreflective assembly as claimed in claim 7, wherein the

softening temperature of the fabric is higher than the melting temperature of the adhesive.

9. A retroreflective assembly as claimed in claim 8, wherein the softening temperature of the fabric is at least 20°C higher than that of the adhesive.

10. A retroreflective assembly as claimed in any preceding claim, wherein the fabric comprises a non-woven fabric.

11. A retroreflective assembly as claimed in claim 10, wherein the fabric is of the heat bonded type.

12. A retroreflective assembly as claimed in any preceding claim, wherein the fabric is of thickness in the range 50 to 500μm.

13. A retroreflective assembly as claimed in claim 12, wherein the fabric is of thickness in the range 50 to 300μm.

14. A retroreflective assembly as claimed in claim 13, wherein the fabric is of thickness in the range 100 to 250μm.

15. A retroreflective assembly as claimed in any preceding claim, wherein the mass of the fabric is in the range 5 to 75g/m^2.

16. A retroreflective assembly as claimed in claim 15, wherein the mass of the fabric is in the range 10 to 35g/m^2.

17. A retroreflective assembly as claimed in any preceding claim, wherein the fabric is formed from filaments of diameter less than 200μm.

18. A retroreflective assembly as claimed in claim 17, wherein the

filaments are of diameter less than 100μm.

19. A retroreflective assembly as claimed in claim 18, wherein the filaments are of diameter in the range 5 to 40μm.

20. A retroreflective assembly as claimed in any preceding claim, wherein the average length of filaments forming the fabric exceeds 2cm.

21. A retroreflective assembly as claimed in any preceding claim, wherein the fabric is formed from polypropylene and has a melting temperature in the range 120 to 180°C.

22. A retroreflective assembly as claimed in any preceding claim, wherein the fabric is formed from Nylon and/or polyester and has a melting temperature in the range 190 to 255°C.

23. A retroreflective assembly as claimed in any preceding claim, wherein the activation temperature of the adhesive is in the range 100 to 120°C.

24. A retroreflective assembly as claimed in any preceding claim, wherein the elements suitable for retroreflective purposes comprise glass or polymer microspheres of diameter in the range 40 to 150μm.

25. A retroreflective assembly as claimed in claim 24, wherein the microspheres are of diameter in the range 50 to 85μm.

26. A retroreflective assembly as claimed in either claim 24 or 25, wherein the microspheres are partially metallised, with the metallised part being embedded in the adhesive.

27. A retroreflective assembly as claimed in any preceding claim, wherein the adhesive is presented on opposite sides respectively of the fabric.

28. A retroreflective assembly as claimed in any of claims 1 to 26, wherein the adhesive is disposed to present an adhesive surface on one side only of the fabric.

29. A retroreflective assembly as claimed in any preceding claim, wherein the fabric includes hydrophilic and hydrophobic fibres presented on opposite sides respectively.

30. A retroreflective assembly as claimed in any preceding claim, wherein the substrate is rendered impermeable by the adhesive.

31. A retroreflective assembly as claimed in any preceding claim further comprising a barrier film disposed on the fabric substrate, in order to render the substrate impermeable.

32. A retroreflective assembly as claimed in claim 31, wherein the barrier film comprises a flexible plastic film.

33. A retroreflective assembly as claimed in claim 32, wherein the barrier film is less than 35μm thick.

34. A retroreflective assembly as claimed in any of claims 31 to 33, wherein the barrier film has a softening temperature higher than that of the adhesive.

35. A retroreflective assembly as claimed in claim 34, wherein the barrier film has a melting temperature higher than that of the adhesive.

36. A retroreflective assembly as claimed in any of claims 1 to 22 or 24 to 35 when appendant directly or indirectly to any of claims 1 to 22 wherein the adhesive is a pressure sensitive adhesive.

37. A retroreflective assembly substantially as herein described with reference to Figures 1 and 4 or 2 and 4 or 3 and 4 or 5 and 6 or 7 and 8 of the accompanying drawings.

38. A method of manufacture of a retroreflective assembly of the type claimed in any preceding claim comprising the steps of: providing a fabric substrate, applying an adhesive to the fabric substrate and partially embedding some elements suitable for retroreflective purposes in the substrate.

39. A method of manufacture of a retroreflective assembly comprising the steps of: providing a fabric substrate, applying an adhesive to the fabric substrate and partially embedding some elements suitable for retroreflective purposes in the adhesive.

40. A method as claimed in claim 39 further comprising the step of: joining a light transmissive top cover to the substrate.

41. A method as claimed in claim 40, wherein the top cover is joined to a substrate with narrow bonds which divide the space between the substrate and top cover into cells in which the elements suitable for retroreflective elements have an air interface.

42. A method as claimed in either claim 40 or 41, wherein the bonds are

formed by the adhesive, by applying external heat and/or pressure and/or by R.F. welding techniques.

43. A method as claimed in any of claims 39 to 42, wherein the adhesive is solvent based and further comprising the step of: causing the adhesive to dry once applied to the fabric.

44. A method as claimed in claim 43, wherein the adhesive is a water based polymer adhesive.

45. A method as claimed in either claim 43 or 44 further comprising the step of: reactivating the adhesive by heating before embedding the elements suitable for retroreflective purposes therein.

46. A method as claimed in any of claims 39 to 45, wherein the adhesive is applied to one side only of the fabric so that the adhesive is disposed to be presented on one side only of the fabric.

47. A method as claimed in any of claims 39 to 45 further comprising the step of: modifying the surface energy characteristics of one side only of the fabric, before applying the adhesive.

48. A method as claimed in claim 47, wherein the fabric surface energy of the fabric is modified by corona arc discharge treatment.

49. A method as claimed in either claim 47 or 48, wherein the surface energy characteristics of one side of the fabric are modified so that when the adhesive is applied it impregnates only a proportion of the thickness of the fabric.

50. A method as claimed in any of claims 47 to 49, wherein the fabric substrate is hydrophobic and the surface energy is modified to render it hydrophilic.

51. A method as claimed in either claim 49 or 50 when appendant to claim 49, wherein the adhesive impregnates less than 100μm of the depth of the fabric.

52. A method as claimed in any of claims 39 to 51 further comprising the steps of: providing a barrier film and joining this to the fabric substrate to render it impermeable.

53. A method as claimed in claim 52 when appendant directly or indirectly to claim 40, wherein the barrier film is joined to the fabric in the same operation as the top cover.

54. A method as claimed in claim 40 and any of claims 41 to 53 when appendant directly or indirectly to claim 40 further comprising the step of: cross-linking the adhesive once the substrate has been joined to the top cover.

55. A method of manufacture of a retroreflective assembly substantially as herein described with reference to Figures 1 and 4 or 2 and 4 or 3 and 4 or 5 and 6 or 7 and 8 of the accompanying drawings.

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Application No: GB 9916938.5
Claims searched: 1-55

Examiner: Richard Kennell
Date of search: 12 October 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B2E (EKB, EM, EQ)

Int Cl (Ed.6): G02B 5/128

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	GB 1424754 A	(MINNESOTA MINING), whole document	X:1,3,38, 40 at least Y: 4,41 at least
X	GB 0788782 A	(HALSTEAD), whole document	1,3,31,32, 38,40,52 at least
X	GB 0559261 A	(STEVENS), see particularly backing layer 10 (page 3 lines 2-69)	1,31,38,52 at least
X	EP 0498581 A	(MINNESOTA MINING), see page 5 lines 13-18 for adhesive	1,38 at least
Y	EP 0399815 A	(MINNESOTA MINING), see bonds 22 and barrier layer 20	4,41 at least
X	EP 0372727 A	(MINNESOTA MINING), see web 26, and cover layer at page 4 line 4-5	1,3,38,40 at least
Y	EP 0291205 A	(MINNESOTA MINING), see bond lines 36	4,41 at least
X	WO 95/30255 A	(MINNESOTA MINING), whole document	1,38 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E [illegible]

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Application No: GB 9916938.5
Claims searched: 1-55

Examiner: Richard Kennell
Date of search: 12 October 1999

Category	Identity of document and relevant passage		Relevant to claims
X	WO 88/01939 A	(OFFRAY), see Figure 3	1,38 at least
Y	US 4653854 A	(MIYATA), see cells 7	4,41 at least
X	US 4263345 A	(BINGHAM), whole document	1,38 at least
X,Y	US 3934065 A	(TUNG), whole document	X:1,3,38, 40 at least Y: 4.41 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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